Jefferson Lab FY03 R&D Activities in Support of RIA

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JLab FY03 Tasks

Low level rf control development

- Finalize and refine the RIA requirement document
- Develop a MATLAB model including cavity and rf system
- Explore effectiveness of electronic damping of microphonics

Cryomodule measurements

- Perform measurements on SNS cryomodules
  - Microphonics
  - Lorentz and piezo tuner transfer functions
- Assess suitability of unmodified SNS cavities and CM for RIA
- Investigate minor modifications and optimize design of components

Low Level RF Development Status

Collaborations

- DESY and Cornell (Video Conferencing)
  - LLRF design comparisons
  - Vendor tool assessments
- SNS LLRF redesign

MATLAB/Simulink Model

- Model for medium beta SRF cavity exists
  - Based on Simulink library for RF systems developed at TTF
  - Includes beam loading, klystron saturation characteristics
  - Operating Modes: Self-excited loop, Generator driven resonator
  - Proportional controllers: I/Q, Amplitude and phase
- Lorentz force detuning
- Incorporates measured data from SNS cavities

Future LLRF Activities

Develop and incorporate microphonics model using white noise process

Analysis of electrical damping of mechanical modes

Investigate reduction of microphonics with piezo tuner

Complete requirements document

Measurements on SNS Cryomodules

Couplers

Tuners resolution and hysteresis

} **OK for RIA**

Transfer functions

- **Lorentz (AM-FM)**
- **Piezo tuner**

Different from each other

Microphonics

- **Amplitude**
- **Frequency spectrum**

Suitability for RIA is an unresolved issue.

} **Vary from cavity to cavity**

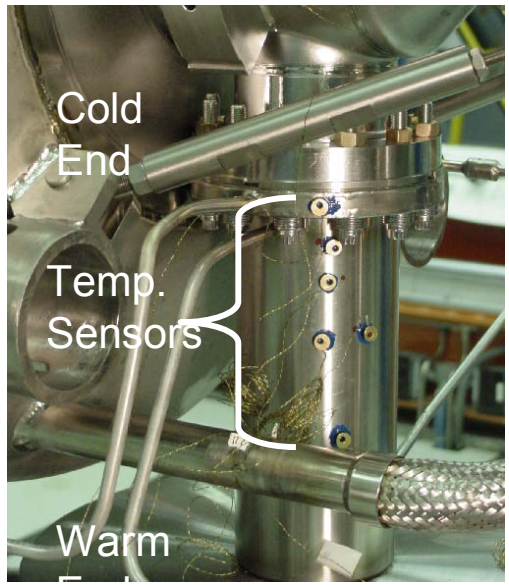
RF Power Couplers

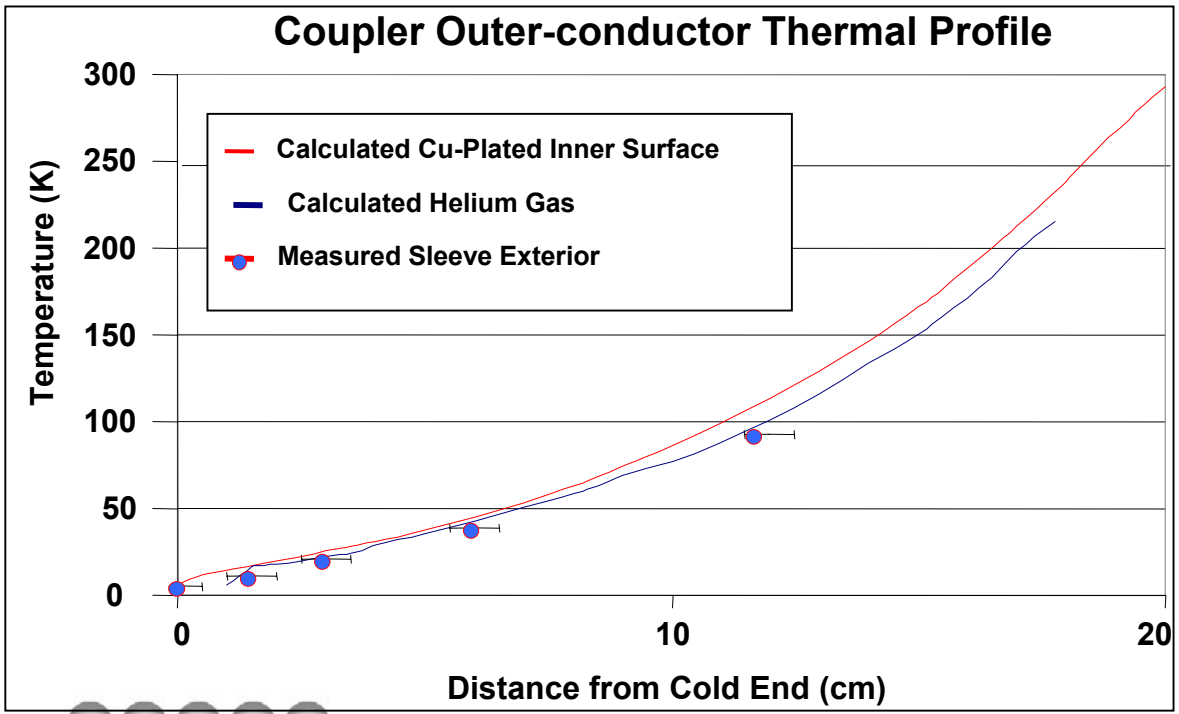
RIA Requirements

- ~20 kW CW, 10 MV/m

SNS Prototype CM

- Good results at 100 kW CW & 9 MV/m
- Agreed with predictions



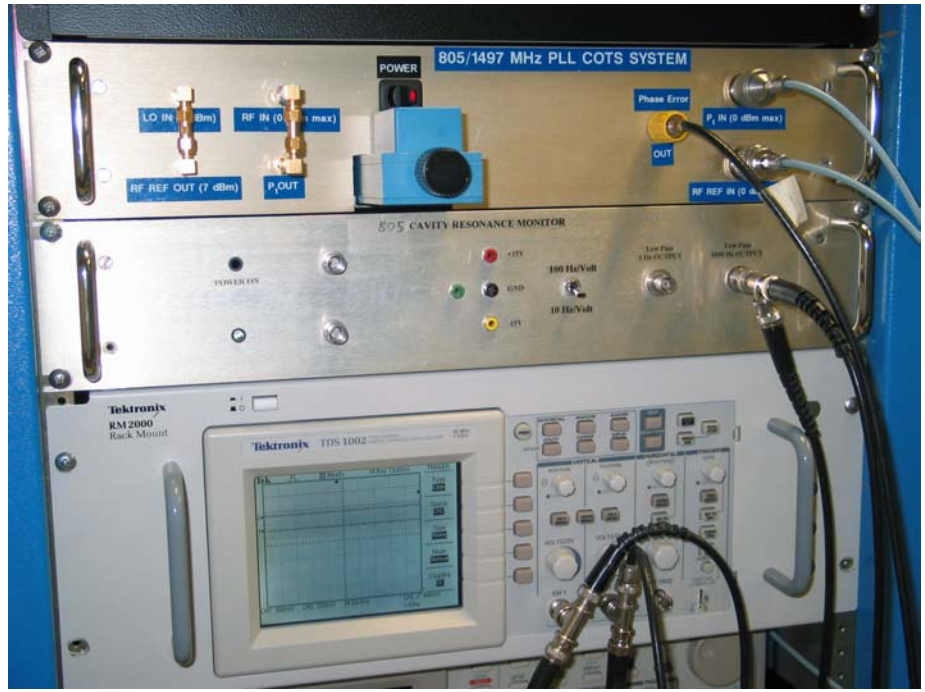


Couplers shouldn't be a problem

Cavity Resonance Monitor

Properties

- Generates a voltage proportional to instantaneous frequency deviation from a stable reference
- 50 db input dynamic range
- Selectable options
  - Gain 10Hz/V or 100 Hz/V
  - Low pass 1 Hz or 1 kHz
  - Bandpass 1 Hz to 1 kHz
- Portable



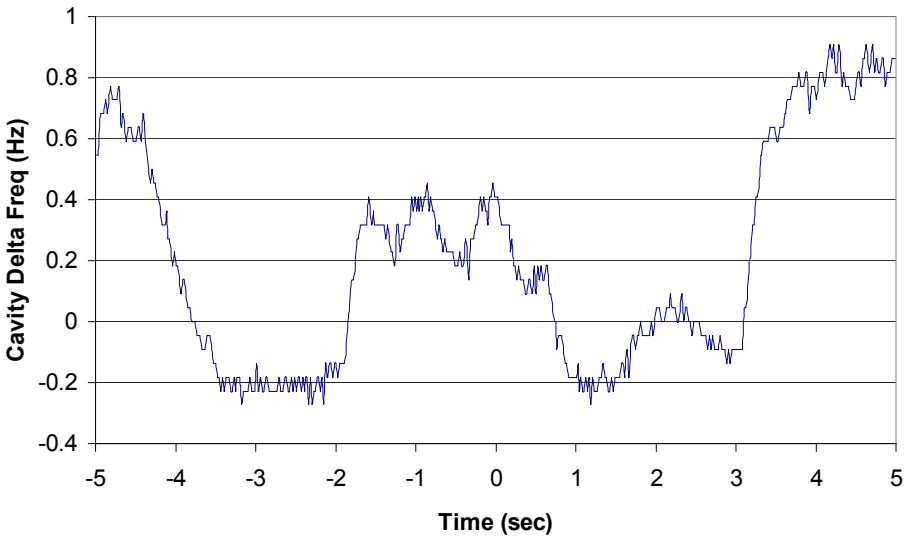
Uses

- SNS
- CEBAF
- RIA (could be used for all)
  - Spoke cavity has been measured at ANL
  - Can be used to measure elliptical cavities at MSU

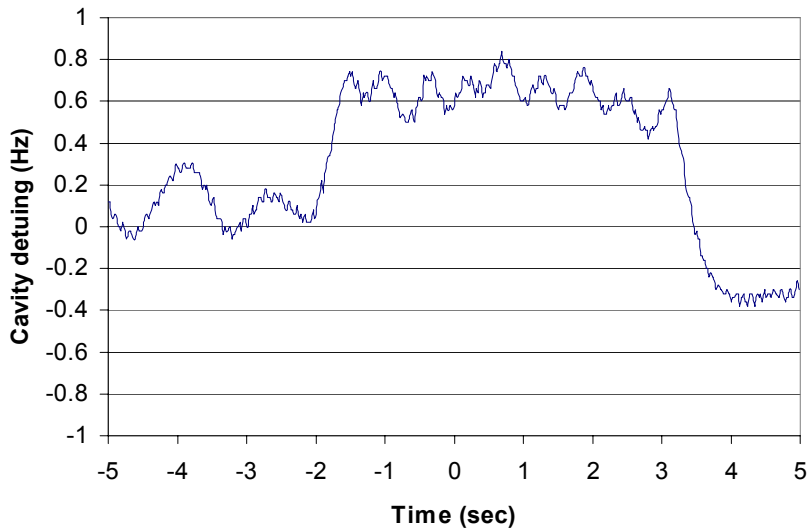
Mechanical and Piezo Tuners

- ~1 Hz resolution and deadband for both the piezo and mechanical tuners.
- Tuner-generated microphonics are acceptable if ramping is slow.
  - Square step: microphonics equal to the tuner step
  - 10 msec ramp: microphonics reduces to <1/4 of tuner step size

Piezo tuner driving SNS M01-1



Mechanical tuner driving SNS M02-3



Microphonics: Probability Density

(Note: Slow drift has been removed)

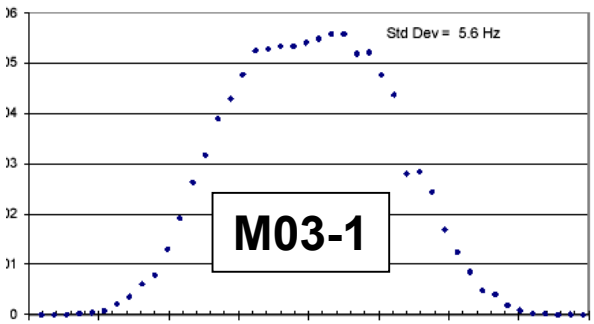
Baseline number

- SNS: 17 Hz
- CEBAF & RIA: <3.5 Hz
  - Usually achieved
  - Sometimes exceeded

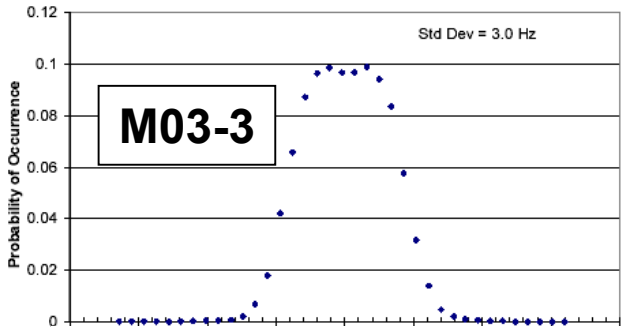
Substantial differences

- Between cavities
- Temporal

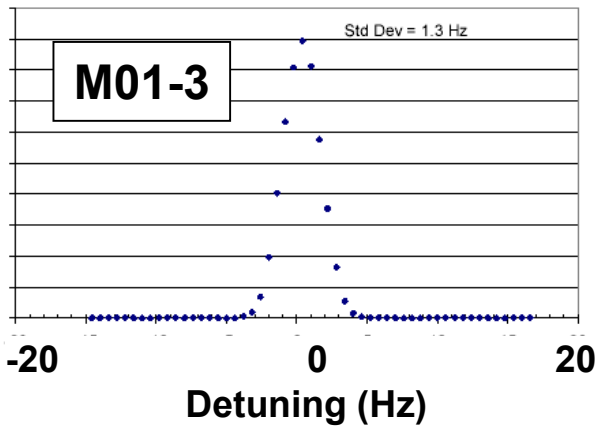
σ = 5.6Hz



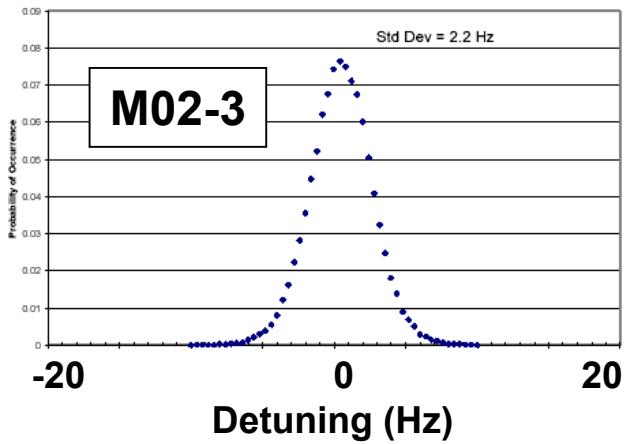
σ = 3.0Hz



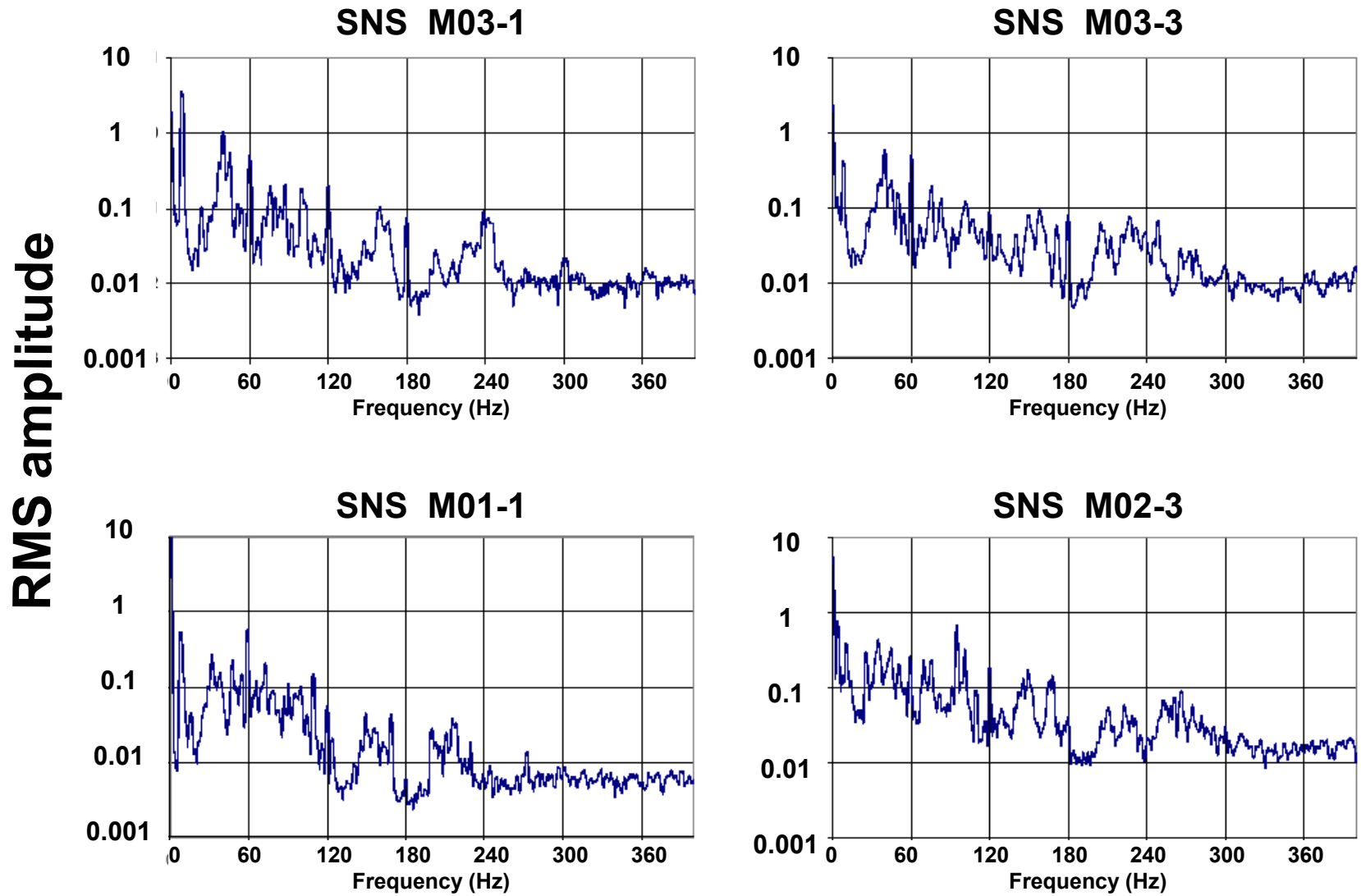
σ = 1.3Hz



σ = 2.2Hz



Microphonics: Frequency Spectrum of RMS Amplitude



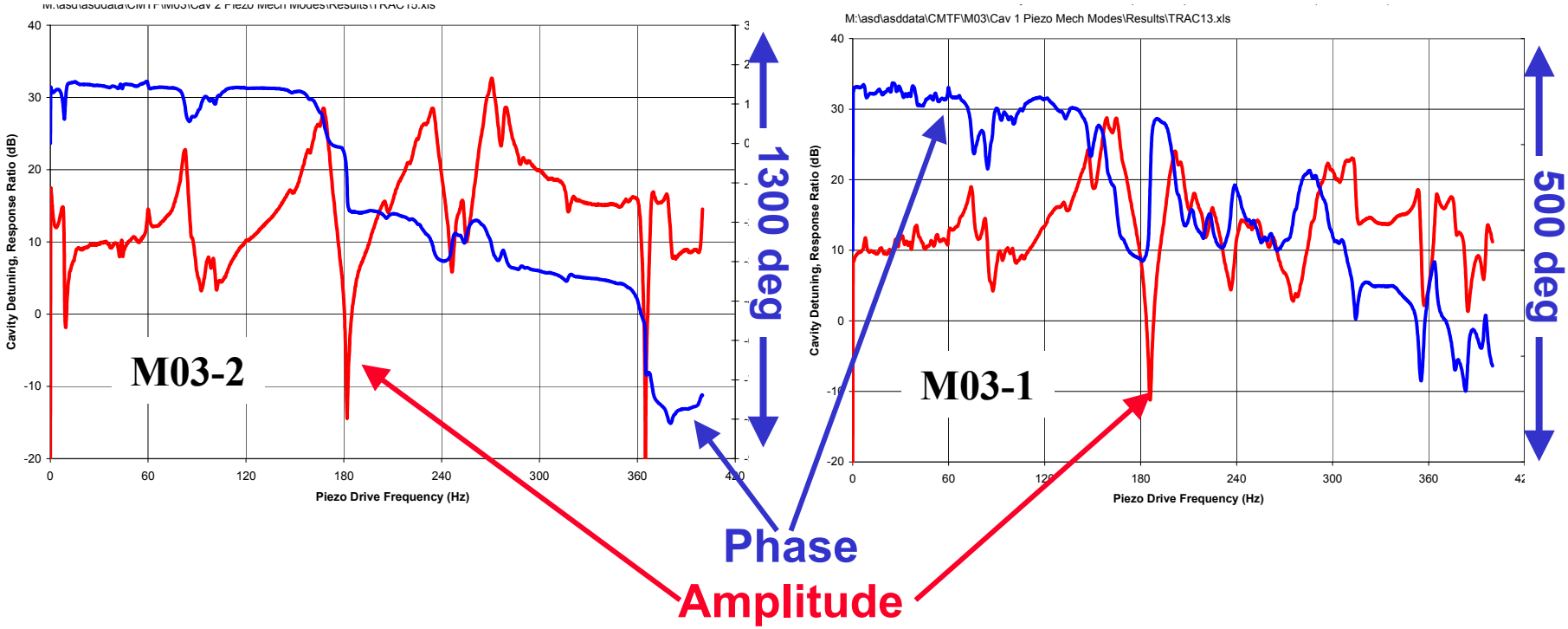
Piezo Tuner Transfer Function: Reduce the microphonics using the piezo

Methodology

- Sinusoidal voltage driving piezo tuner
- Ramp frequency & excite mechanical modes in succession

Substantial differences observed between cavities, (especially phases)

Cavity-specific data must be incorporated in LLRF model & control



Lorentz Transfer Function (AM-FM): Use electronic damping to reduce microphonics

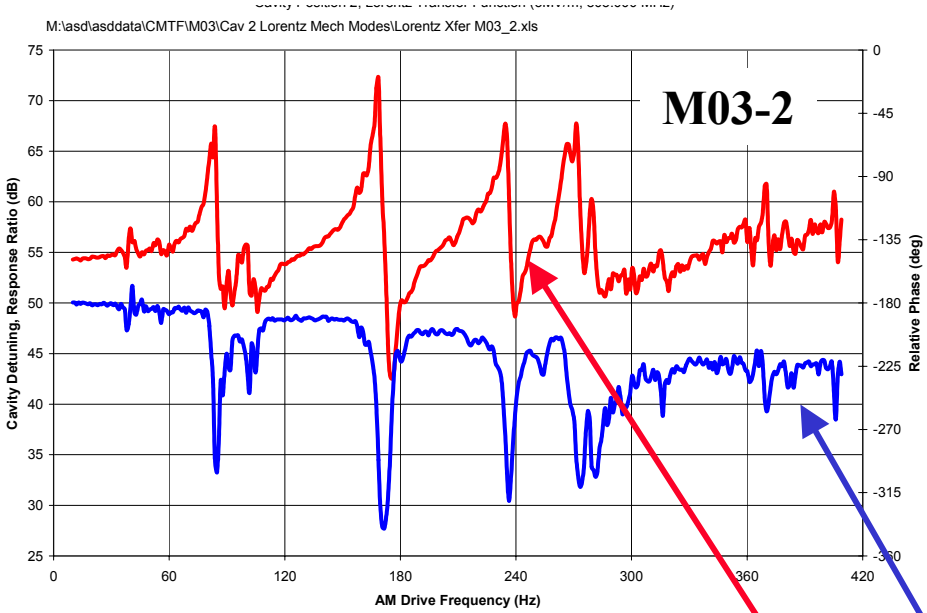
Methodology

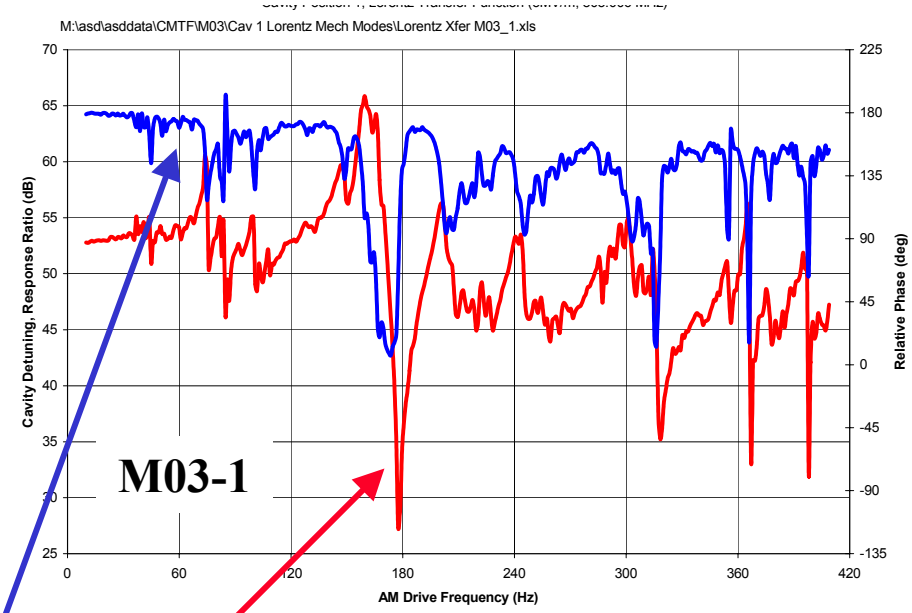
- Sinusoidal modulation of cavity field amplitude
- Ramp frequency & excite mechanical modes in succession

Substantial differences seen:

1) between cavities and 2) from piezo transfer function

Cavity-specific data must be incorporated in LLRF model & control





Phase

Amplitude

Future Measurement and System Integration Activities

Funded

- Continue measurements on SNS cryomodules (medium and high beta)

Proposed

- Complete development of a LLRF control system suitable for a wide range of applications
- Perform measurements on other RIA cavities
- Perform an integrated test of a RIA driver cryomodule + RF system (original proposal)